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Outbreak of Vesicular Stomatitis in Swine and Its Differential Diagnosis From Vesicular Exanthema and Foot-and-Mouth Disease

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CONTENTS

OUTBREAK IN COMMERCIAL BIOLOGICAL ESTABLISHMENT

On August 7, 1943, a report of an outbreak of an exanthematous disease was received in Washington, D. C., by the Chief of the Bureau of Animal Industry from the inspector in charge at a licensed establishment engaged in the production of anti-hog-cholera serum and hog-cholera virus at Kansas City, Kans. The outbreak occurred among hog-cholera immune and hyperimmune hogs used in the preparation of anti-hog-cholera serum at the establishment. These hogs were on that part of the premises known as the hog cholera unit, the floor plan of which is shown in figure 1. The report showed that the first suspicious symptoms of the disease were observed on July 26, 1943, when the temperatures of a group of 116 hyperimmunized hogs were being taken prior to the first bleeding. Owing to high temperatures (104°

[1] The diagnosis and control of this outbreak of vesicular stomatitis were greatly facilitated by the assistance rendered by the Federal inspectors and various officials and other employees of the establishment. The directors of the establishment were most helpful in providing facilities for carrying out this work and in adopting the various procedures necessary for controlling the disease and safeguarding the biological products. The writers are especially indebted to F. A. Imler (deceased) and E. L. Mundell of the Bureau force, and to E. F. Sanders, in charge of operations at the establishment.

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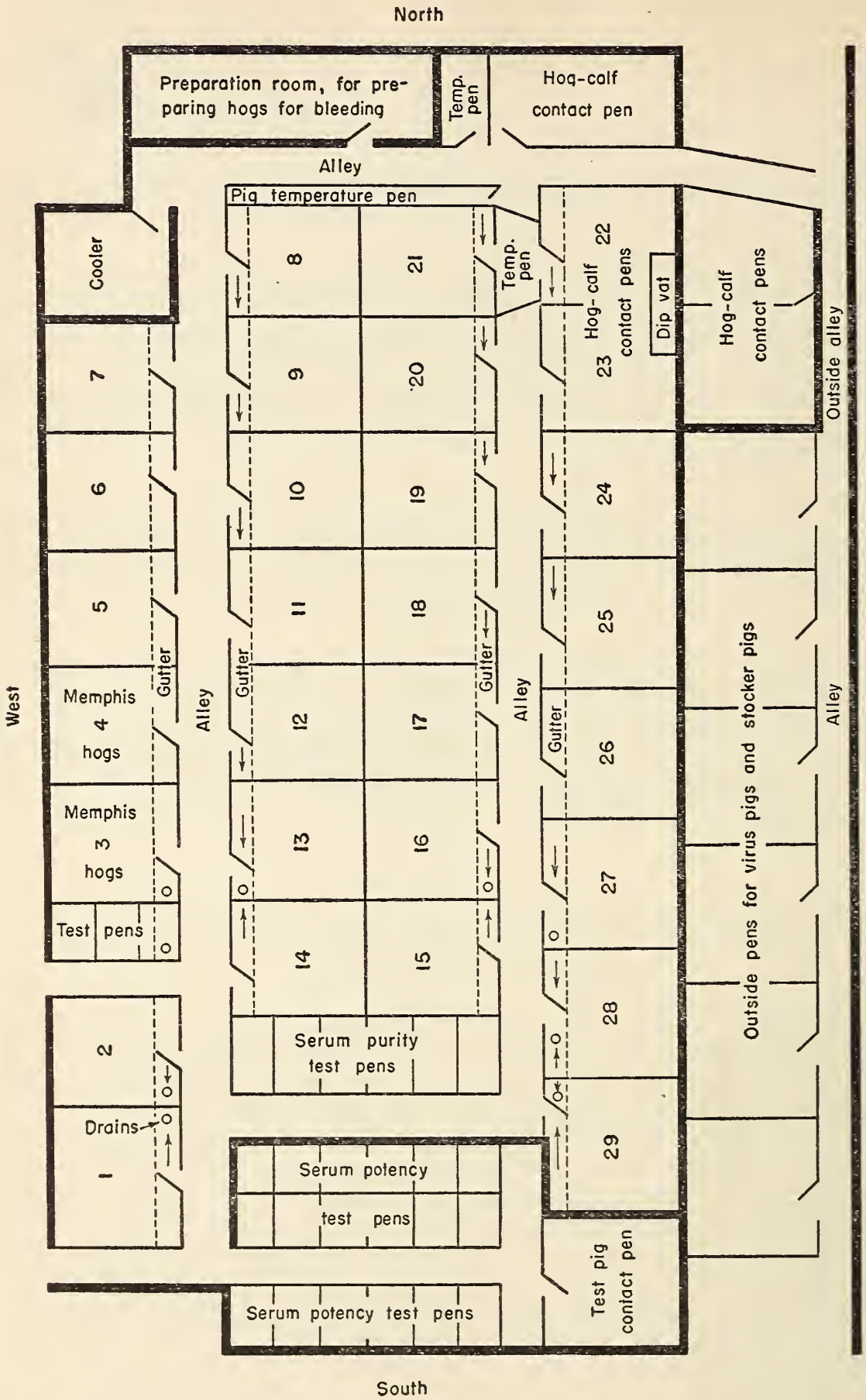

FIGURE 1.—Floor plan of the hog cholera unit.

F. or above), 41 of these hogs were rejected for bleeding. Of these 41 hogs, 35 were from a shipment of 60 cholera-immune hogs received on July 10 from a farm near Memphis, Tenn., and hyperimmunized on July 14; and 6 were from 56 immunes from a local garbage-feeding establishment, these animals also being hyperimmunized on July 14.

The report stated that when these hogs were being driven to the temperature pen many in the Memphis group evidenced lameness, which became less pronounced on continued movement. Two or three days later lameness became more pronounced in the Memphis hogs, and sores on their feet were found. All immune hogs purchased by the establishment had been garbage-fed and, as frequently occurs in such animals, their feet had numerous cuts, sores, and abrasions, sometimes resulting in lameness.

On August 4 lameness was reported also in 46 of a group of 178 immune hogs just prior to hyperimmunization, and vesicular lesions on the feet with sloughing of the affected epithelium were found. Most of this group had been on the premises for only 1 week and the remainder for not more than 2 weeks, indicating that the infection had spread from the originally infected swine. It was apparent from this spread that an infectious condition was present. Owing to the similarity of the foot lesions to those characteristic of foot-and-mouth disease, the potentially serious nature of the disease became apparent. A quarantine was therefore placed on the premises.

Immediately after receiving this report, the writers went to Kansas City to diagnose the nature of the malady and to determine whether the biologics prepared by this concern were contaminated and what disposition should be made of all animals on the premises.

EXAMINATION OF EXPOSED ANIMALS

On arrival at the quarantined area on August 8, the writers made a survey of the hog-cholera unit, which was approximately 120 by 200 feet in size. It contained about 1,300 animals, of which 787 were large immune and hyperimmune hogs in 29 holding pens (numbered pens shown in fig. 1) in 1 large covered shed. Adjoining this shed were pens holding approximately 500 virus, stocker, and test pigs. In addition there were, on these premises, 12 yearling calves exposed by direct and indirect contact to the immune and hyperimmune hogs. In accordance with regulations of the Bureau, these calves, hereafter known as contact calves, were used as controls to determine the possible presence of foot-and-mouth disease in swine used for producing anti-hog-cholera serum. Of the virus, stocker, and test pigs, only 1 animal showed any indication of infection and it had been on the premises only 5 days. All calves were apparently normal.

Among the immune and hyperimmune hogs, lame animals were observed in practically every pen. Approximately 30 of these hogs were examined individually to determine the type and extent of lesions. With few exceptions, lesions were found only on the feet; 1, 2, 3, or sometimes all 4 feet in individual animals were affected. The extent of foot lesions varied from simple loosening or sloughing of the bearing surface of the hoof to extension throughout the interdigital space upward and around the coronary band of 1 or both claws. In the more severe cases, loosening of the horny wall occurred, and in many instances the wall sloughed off and the inflamed laminae were

exposed. These severely affected animals were unwilling to rise, and as a result decubital sores formed on the skin covering the joints of the legs. Secondary infection occurred in these skin lesions, resulting in extensive swelling of the joints of the legs. One hyperimmune hog that had been rejected for final bleeding on the previous day had severe lesions on all 4 feet and extensive erosions covering the entire snout and extending as far as one could see into the right nostril. The condition of this hog was typical of vesicular exanthema or foot-and-mouth disease in a severe form.

INSPECTION OF PREMISES ON WHICH SWINE ORIGINATED

The immune hogs used in the preparation of anti-hog-cholera serum at this establishment were purchased mainly from a local garbage-feeding establishment and from a similar one near Chicago. On few occasions garbage-fed immune hogs were also purchased from other sources. The virus, stocker, and test pigs were obtained through individual agents in Missouri and Kansas. Arrangements were immediately made to have the premises from which all the swine originated inspected by State or Federal veterinarians for the presence of any exanthematous disease. The results of such investigations, which were intensively carried on for the next few days, were negative in all instances.

DIAGNOSIS OF THE DISEASE

On August 6, 2 days before the arrival of the writers, the veterinarian in charge of production at this establishment inoculated two contact calves, two pigs, and three guinea pigs with fluid from an unbroken vesicle on a hog. No lesions appeared in the calves, but erosive lesions were found in the inoculated areas on the feet of the two pigs. The guinea pigs had been inoculated on the median pad of both forefeet and had abscess formations that were not typical of vesicular stomatitis or foot-and-mouth disease.

The occurrence of lesions in swine, but not in calves, in this inoculation test indicated that the infection might be vesicular exanthema of swine (table 1). This disease had been found only in California, where an extensive outbreak occurred in 1943. It was believed, therefore, that the spread of this disease might have resulted from shipments of fresh pork products to various Army camps outside of California and thus to hog ranches feeding garbage from Army camps.

On August 9 search was made by the writers among the large hogs in the establishment until three were found with lesions sufficiently fresh for diagnostic inoculations of experimental animals. Approximately 3 gm. of affected epithelial tissue from the three hogs was emulsified in 35 cc. sterile isotonic sodium chloride solution. This furnished the material for epithelial inoculations of the animals shown in table 2, six guinea pigs, and several animals used in later experiments. None of the animals had previously been on the premises of the establishment. They therefore were considered to be susceptible to the disease.

In the two horses, inoculated on the epithelium of the tongue, blanching in this area occurred in 22 hours accompanied with a rise

TABLE 1.—*Susceptibility of various species of animals to viruses of exanthematous diseases, as determined in previous investigations* [1]

Species	Method of exposure	Foot-and-mouth disease [2]	Vesicular stomatitis	Vesicular exanthema
Horses	Natural	−	+	−
	Epithelial	−	+	[3] ?
Cattle	Natural	+	+	−
	Epithelial	+	+	−
	Subcutaneous	+	−	
	Intramuscular	+	−	
	Intravenous	+	[4] ?	
Swine	Natural	+	−	+
	Epithelial	+	+	+
	Subcutaneous	+	−	[5] +
	Intramuscular	+	−	[5] +
	Intravenous	+	+	[5] +
Goats	Natural	+	−	−
	Epithelial	+	−	−
Guinea pigs	Natural	−	−	−
	Epithelial	+	+	−

[1] +, susceptible; −, nonsusceptible; ?, questionable.

[2] Owing to the highly infectious nature of foot-and-mouth disease, the experimental work on this disease has been done in foreign countries.

[3] CRAWFORD, A. B. EXPERIMENTAL VESICULAR EXANTHEMA OF SWINE. Amer. Vet. Med. Assoc. Jour. (n. s. 43) 90: 380–395, illus. 1937. Some strains of virus regularly produce lesions in equines; others are innocuous.

[4] OLITSKY, P. K., TRAUM, J., and SCHOENING, H. W. REPORT OF FOOT-AND-MOUTH-DISEASE COMMISSION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE. U. S. Dept. Agr. Tech. Bul. 76, 172 pp., illus. 1928. This report states that of 8 cattle, 2 developed lesions and 6 were refractory. (See pp. 122–123.)

[5] Reported by J. Traum, Division of Veterinary Science, University of California, in a personal communication.

in temperature of about 2.5° F. In 46 hours, the epithelium over a sharply circumscribed area about 2 inches in diameter had sloughed, leaving a narrow fringe of necrosed epithelium. The denuded area was raw and glistening and had a punched-out appearance. Salivation was profuse at this time and the temperature had returned to normal. There was no extension of lesions.

The two cattle in table 2 as well as one in table 3, also exposed by scarification of the dental pad, developed vesicular lesions that spread only slightly beyond the scarified area. In two of these animals, this area was slightly inflamed in 24 hours and vesiculation was present in 48 hours. In the third bovine, blanching occurred in 48 hours and vesiculation in 72 hours. There was little temperature reaction. As a matter of fact, the temperature of each animal was more than 105° F. at the time of inoculation, probably due to excitability and high atmospheric temperature (about 100°), and the temperatures of the animals varied between 102.4° and 103.2° at time of vesiculation. In none of these animals were there any foot lesions or secondary lesions.

The swine used in the diagnostic test weighed from 70 to 300 pounds. Two had slight lesions on the snout, one had fairly well-marked lesions, and two had extensive lesions. The temperature was a fairly good index of the severity of the disease. In the slightly affected animals the temperature did not rise above 103.6° F., whereas in the severely affected animals it rose to 106° or more and tended to remain elevated for several days, especially when there was peripheral extension of lesions. When the lesions were slight, erosions only were seen; but in severe infections, thin-walled vesicles containing 0.5 to 3 cc. of clear, straw-colored vesicular fluid appeared. In several instances there were extensions of lesions deep in one or both nostrils. Primary lesions usually occurred within 48 hours after inoculation, and the affected epithelium could be removed at that time.

TABLE 2.—*Effect, on various species of animals, of epithelial inoculations with Kansas City virus*

Species and No.	Method of inoculation	Source of inoculation	Preliminary temperature of test animal (°F.)	Results after—		
				24 hours	48 hours	72 hours
Horse:						
667	Scarification of epithelium of tongue.	Foot lesions of hogs 4803,4808, 4853.	101.2	Temperature 103.8°; blanching of epithelium over an area 1.5 by 2 inches.	Temperature 100.0°; epithelium in area 1.5 by 2 inches sloughed leaving narrow fringe of necrosed tissue on sharply circumscribed margin; extensive salivation.	Temperature 100.2°; denuded area raw, with punched-out appearance; no extension of lesions.
668	do	do	100.8	Temperature 103.6°; blanching of area 0.5 inch in diameter adjacent to lower edge of scarification.	Temperature 100.6°; epithelium over area 1 by 2.5 inches sloughed, leaving narrow fringe of necrosed tissue on sharply circumscribed margin; extensive salivation.	Temperature 101.0°; beginning healing along margin of denuded area.
Cattle:						
546	Scarification of dental pad.	do	105.4	Temperature 102.2°; area of scarification slightly inflamed.	Temperature 102.6°; epithelium over an area 0.5 by 2.5 inches blanched, thickened, and loose, margin sharply circumscribed.	Temperature 103.4°; denuded area covered with grayish-yellow exudate; salivation.
549	do	do	105.4	Temperature 101.9°; area of scarification slightly inflamed.	Temperature 102.4°; epithelium over an area 0.7 by 2.5 inches blanched, thickened, and loose, margin sharply circumscribed.	Temperature 102.0°; denuded area raw and congested; no extension of lesions; salivation.
Swine:						
106	Scarification of snout	do	102.8	Temperature 101.8°; no lesions	Temperature 102.4°; epithelium 1.5 inches in diameter at site of inoculation eroded, with slight vesiculation on margins.	Temperature 102.4°; no extension of lesions.
107	do	do	102.2	Temperature 103.0°; no lesions	Temperature 103.6°; slight erosion at site of inoculation.	Temperature 102.6°; slight peripheral extension of lesions with vesiculation.
108	do	do	103.4	do	Temperature 105.0°; 2 vesicles, each 0.5 inch in diameter on margin of inoculated area; 2 cc. of clear fluid aspirated.	Temperature 103.0°; denuded areas on snout raw and congested.
109	do	do	103.0	Temperature 103.2°; no lesions	Temperature 103.2°; scarified area slightly blanched.	Temperature 106.2°; only slight lesions in spite of high temperature.
110	do	do	104.0	Temperature 102.4°; no lesions	Temperature 103.8°; no lesions	Temperature 106.0°; tip of snout swollen; erosions extending downward between nostrils; on following day large vesicle on border of snout.
Goat:						
101	Scarification of dental pad.	do	105.0	Temperature 103.8°; slight reddening of scarified area.	Temperature104.6°; no lesions	Temperature 104.0°; no lesions.
102	do	do	105.4	Temperature 104.0°; slight reddening of scarified area.	Temperature 103.4°; no lesions	Temperature 103.6°; no lesions.

The two goats, inoculated by scarification of the dental pad, were refractory. One developed a slight transient reddening at the site of inoculation, but no vesiculation or spread occurred and there was no change in temperature.

As practically the same results were obtained for all six guinea pigs used in these diagnostic tests, the data for this species of animals are not given in table 2. After inoculation by scarification of the metatarsal pads, blanching occurred within 24 hours and vesiculation with loosening of the pads within 48 hours. The pad lesions were typical of those caused by the stock strains of Indiana and New Jersey types of vesicular stomatitis virus.

A comparison of the results obtained from the various species of animals with the data in table 1 indicated that the disease was vesicular stomatitis.

DETERMINING WHETHER KANSAS CITY VIRUS CONFORMED WITH KNOWN TYPES THAT PRODUCE VESICULAR STOMATITIS

There have been numerous outbreaks of vesicular stomatitis in horses and cattle in widely separated areas of the United States. Two immunologically distinct types of virus, the Indiana and New Jersey types, so-called because they were obtained from outbreaks in the respective States, have been recovered. All typed outbreaks in this country have conformed to one or the other of these viruses. Since the Kansas City outbreak of vesicular stomatitis is the first that has been found to occur in swine, it was considered possible that the causal agent might be a new virus. Consequently, on August 11 two experiments were made to determine whether the Kansas City virus agreed with the two known types in filtrability.

In the preparation of the filtrate used in the first experiment, about 2 gm. of material from cattle, horses, and hogs was ground with sterile sand in a sterile mortar and 35 cc. of sterile isotonic sodium chloride solution added gradually. After settling, 30 cc. of the suspension was passed through two layers of sterile gauze to remove coarse particles and then through a Berkefeld N filter. The filtrate was tested aerobically and anaerobically and was found to be sterile. Inoculations with the clear filtrate were made as follows: One hog with 2 cc. intramuscularly, three hogs by scarification of the snout, and six guinea pigs by scarification of the metatarsal pads. As controls, one hog was inoculated intramuscularly with 3 cc. of the unfiltered material, two hogs on the scarified snout, and two guinea pigs by scarification of the metatarsal pads. Forty-eight hours later two of the three hogs inoculated on the snout with the filtrate had typical lesions surrounding the site of the inoculation. The intramuscularly injected hog and the guinea pigs failed to develop lesions. The two hogs and the two guinea pigs inoculated by scarification with the unfiltered material had typical lesions, whereas the hog injected intramuscularly with the same material was refractory. Detailed results of the experiment are shown in table 3.

The second experiment was made with infected guinea pig pads. Approximately 1.5 gm. of material was ground with sterile sand in a sterile mortar, and 20 cc. of sterile isotonic sodium chloride solution

TABLE 3.—*Results of first filtrate experiment (inoculum from lesions of cattle, horses, and hogs)*

Species and No.	Method of inoculation	Preliminary temperature	Results after—		
			24 hours	48 hours	72 hours
INOCULATIONS WITH FILTRATE					
Hog:		(°F.)			
82	Intramuscular	103.0	Temperature 103.2°; no lesions	Temperature 102.0°; no lesions	Temperature 103.4°; no lesions.
83	Scarification of snout	103.4	Temperature 103.8°; no lesions	Temperature 102.4°; no lesions	Do.
84	do	102.8	Temperature 103.0°; no lesions	Temperature 103.6°; slight blanching of epithelium and slight vesiculation.	Temperature 102.8°; only slight lesions.
85	do	103.0	Temperature 103.6°; no lesions	Temperature 103.6°; unbroken vesicle on margin of right nostril.	Temperature 103.6°; another vesicle formed in scarified area. On next day two vesicles formed by extension in right nostril.
Guinea pig:					
726	Scarification of metatarsal pads.	(1)	No lesions	No lesions	No lesions.
727	do	(1)	do	do	Do.
728	do	(1)	do	do	Do.
729	do	(1)	do	do	Do.
730	do	(1)	do	do	Do.
731	do	(1)	do	do	Do.
INOCULATIONS WITH UNFILTERED SUSPENSION					
Hog:					
86	Intramuscular	(1)	No lesions	No lesions	No lesions.
87	Scarification of snout	(1)	do	Temperature 102.8°; entire snout blanched with small areas of vesiculation.	Temperature 104.8°; extension of vesiculation into right nostril; next day lame in right hind leg, leg swollen to hock and hot; during next two days vesiculation occurred on pads, interdigital space, and coronary bands.
88	do	(1)	do	Temperature 103.0°; area 1.5 by 2.5 inches from tip of snout to lip and extending into right nostril blanched with beginning of vesicle formation.	Temperature 102.2°; blanched tissue necrosed with slight extension of vesiculation.
Guinea pig:					
732	Scarification of metatarsal pads.	(1)	do	Blanching of right hind pad	Lesions in both hind pads.
735	do	(1)	do	Blanching of both pads	Do.

[1] Temperature not taken.

was added gradually. Of the solution, 15 cc. was filtered through two layers of sterile gauze and then passed through a Berkefeld N filter, and the remaining 5 cc. was kept for control inoculations. The Berkefeld filters were controlled by inoculating three agar Petri plates and three Smith fermentation tubes with each filtrate. All cultures remained sterile. Six guinea pigs were inoculated with the filtrate by scarification of the metatarsal pads. Two guinea pigs were similarly inoculated with the unfiltered suspension. Two of the six guinea pigs inoculated with the filtrate developed lesions of vesicular stomatitis on the inoculated pads 48 to 72 hours later. The two guinea pigs inoculated with the unfiltered material developed characteristic lesions within 48 hours.

The results of these two filtrate experiments proved that the agent causing this outbreak was filter-passing. In later tests at the Bureau's Animal Disease Station, Beltsville Research Center, Beltsville, Md., the virus was found to be identical with the New Jersey type. Furthermore, the first of these two filtrate experiments indicated that the swine were more susceptible to the virus than were guinea pigs.

FURTHER STUDIES OF THE KANSAS CITY VIRUS

In further studies of the Kansas City virus, tests were made on August 9, 12, and 15 to determine whether reactions of animals inoculated intramuscularly, subcutaneously, and intravenously agreed with those shown in table 1 for vesicular stomatitis. On August 9, two hogs (Nos. 104 and 105) were inoculated intramuscularly and one (No. 103) subcutaneously with the same material used in the epithelial inoculation (table 2). On August 12, affected tissue from a hog was used in inoculating two cattle intramuscularly. This tissue was emulsified in the same manner as that used in inoculating the two cattle shown in table 2. On August 15, six hogs were inoculated intravenously, and six guinea pigs by scarification of metatarsal pads, with material prepared as follows: About 1 cc. of clear fluid from an unbroken vesicle, epithelial tissue from a lesion on the snout of each of two large hogs, and epithelial tissue from the dental pad of a steer were emulsified in 25 cc. of isotonic sodium chloride solution and filtered through two layers of gauze. This inoculum represented about a 1:12 suspension of infected material. The results of these experiments, as well as those obtained with hog 86 inoculated intramuscularly with unfiltered suspension and included also in table 3, are shown in table 4.

The two cattle, each injected intramuscularly with 1.5 cc. of the inoculum, failed to develop lesions.

None of the three hogs injected intramuscularly nor the one injected subcutaneously, developed lesions. In one animal, however, there was a considerable rise in temperature (105.4° F.), which occurred 24 hours after inoculation. Whether this was due to the virus of vesicular stomatitis or a contaminant in the inoculum was not determined. The hog did not appear to be off condition at the time of the temperature reaction.

Six normal pigs, of an average weight of about 65 pounds each, received intravenously, in the marginal vein of the ear, 3 cc. of the inoculum. In 44 hours three of the animals, with elevated temperatures of 104.2° to 106° F., were noticeably lame, and one foot of each

TABLE 4.—*Effect of intramuscular, subcutaneous, and intravenous inoculations in cattle and hogs with Kansas City virus*

[Virus used in all these tests was proved to be active by epithelial inoculation of control animals]

Species and No.	Method of inoculation	Source of inoculum	Preliminary temperature of test animal (°F.)	Results after—		
				24 hours	48 hours	72 hours [1]
Cattle:						
169	Intramuscular	Snout lesions of hog 107	104.2	Temperature 101.6°; no lesions.		
170	do	do	104.8	Temperature 101.4°; no lesions.		
Hog:						
86	do	Epithelial lesions from cattle, horses, and hogs.	[2]	No lesions	No lesions	No lesions.
104	do	Foot lesions of hogs 4803, 4808, 4853.	102.8	Temperature 105.4°; no lesions.	Temperature 103.6°; no lesions.	Temperature 104.6°; no lesions.
105	do	do	103.6	Temperature 104.6°; no lesions.	Temperature 103.0°; no lesions.	Temperature 104.2°; no lesions.
103	Subcutaneous, right axillary.	do	103.6	Temperature 103.0°; no lesions.	Temperature 104.6°; no lesions.	Temperature 104.0°; no lesions.
4	Intravenous	Snout lesions of hogs 85 and 88 and dental pad of steer 171.	102.0	Temperature 102.6°; no lesions.	Temperature 104.2°; lame in left hind leg; foot slightly swollen to hock and hot.	Temperature 103.6°; vesicles on coronary band of left hind leg; during next 3 days, temperatures of 103.6°, 105.4°, 103.6°; progressive extension of vesiculation to include interdigital space and dewclaws.
5	do	do	101.8	Temperature 102.8°; no lesions.	Temperature 104.8°; no lesions.	Temperature 104.4°; no lesions.
7	do	do	103.6	Temperature 103.8°; no lesions.	Temperature 106.0°; swelling and blanching of left hind foot; leg hot to hock.	Temperature 105.4°; swelling of left hind foot receding; tip of snout swollen and raised, blanched area between nostrils; on following day temperature of 105.4°; snout lesions shallow and encrusted; vesicles on coronary band of left claw of left hind foot; no further extension.
8	do	do	102.0	Temperature 102.6°; no lesions.	Temperature 102.6°; no lesions.	Temperature 103.0°; no lesions.
9	do	do	102.0	Temperature 102.4°; no lesions.	Temperature 102.4°; no lesions.	Temperature 103.6°; no lesions.
12	do	do	101.0	Temperature 103.4°; no lesions.	Temperature 105.2°; lame in right forefoot; marked swelling of left pad, with blanching.	Temperature 105.4°; vesicles on left claw of left hind foot; right forefoot swollen, pad raised by vesicular fluid; vesicles on adjoining interdigital space; some extension of lesions on following day after which temperature dropped and healing began.

[1] The animals were observed for 18 days; lesions resolved in affected animals, and the others remained normal.

[2] Temperature not taken.

animal was swollen in the region of the coronary band and fetlock. The affected feet were hot on palpation. One of the remaining pigs had a temperature of 104.8°, but neither it nor the other two developed lesions. In 70 hours after inoculation the three pigs that had swelling of the feet on the previous day had definite areas of vesiculation and erosion on the bearing surface of the pads. These lesions extended progressively through the interdigital space and around the coronary bands of the hoof on the 3 following days, after which they began to resolve. The temperatures remained elevated in these three animals until resolution set in.

The results of these tests are in conformity with previously reported studies on the virus of vesicular stomatitis.

In only one instance did a secondary lesion occur in swine or in any other large experimental animal. This was in a shote that developed extensive lesions on the snout 48 hours after inoculation with an unfiltered suspension used in a filter experiment. Forty-eight hours after the development of snout lesions lameness was noted in the right hind leg, which was slightly swollen in the region of the hock. On the following day the swelling extended to the bearing surface of the feet. The swellings were hot on palpation, even through rubber gloves. Two days later vesiculation occurred in the interdigital space and coronary region, and the entire bearing surface of this hoof was loose and pendant.

OBSERVATIONS OF OTHER SUSCEPTIBLE ANIMALS ON THE PREMISES

There were approximately 42 horses, 25 steers, 6 contact calves, and 223 goats on the premises of the establishment, other than in the hog cholera unit, during the time of this outbreak. These animals were observed at frequent intervals during this period, and on August 20 each of these animals was examined individually. In none was there evidence of present or past infection.

DISPOSITION OF THE ANIMALS IN THE HOG CHOLERA UNIT AND DISINFECTION OF PREMISES

On August 23 all hyperimmune hogs having decubital sores, sloughed hoofs, swollen joints, or otherwise in poor condition as a result of the disease were destroyed and tanked. Temperatures of the remaining immune and hyperimmune hogs were taken on 3 successive days. Those with any temperature reaction were likewise disposed of, and the remainder were dipped in a 3-percent cresol solution and placed in cleaned pens. Those hogs and all stocker pigs were slaughtered during the week of August 23, and the carcasses were disposed of to a local abattoir under Federal inspection. On August 30, the 23 swine used in the investigation, all surviving guinea pigs, and the 2 goats used for diagnostic purposes were destroyed. The cattle and horses used in the diagnosis of the disease and the 12 control calves were released on August 30 after a physical examination of each animal. These operations removed all animals from the hog cholera unit.

Beginning on September 6, the floors, walls, and all stationary equipment of the hog cholera unit were thoroughly disinfected with hot

lye solution. The self-feeders in the hog pens in a poor state of repair were removed and burned, and the feeders in good condition, as well as all other movable equipment on the premises, were likewise thoroughly disinfected.

DISPOSITION OF HOG CHOLERA VIRUS AND ANTI-HOG-CHOLERA SERUM

On September 10, in the various pens of the hog cholera unit, tests on 9 batches of simultaneous virus and 23 batches of anti-hog-cholera serum were begun to determine whether these products were contaminated with the virus of vesicular stomatitis. Eight pigs were used for each batch, and each pig received 10 cc. of virus or serum intravenously. These groups of pigs were rotated daily for 15 days in the various pens of the hog cholera unit. This rotation also furnished a test on the efficiency of disinfection. At the end of this test period, all animals were apparently normal. The biologics tested were released for distribution subject to potency tests. The quarantine was removed from the premises. Restocking and resumption of operations were begun immediately after the completion of these tests. There has been no further evidence of vesicular stomatitis in this establishment.

DISCUSSION

Cattle, horses, hogs, and guinea pigs were found to be susceptible to the Kansas City virus, thus definitely identifying it as that of vesicular stomatitis. Goats, the only other species inoculated, were refractory. Calves exposed more or less directly by contact failed to develop the disease. On the other hand, 53 percent of the 787 immune and hyperimmune hogs became infected. Of approximately 500 virus, stocker, and test pigs indirectly exposed, only 1 virus pig was found to be affected. This pig had been on the premises only 5 days.

The fact that six immune hogs from a source other than the Memphis hogs were also apparently affected at the same time as the latter, and that all were hyperimmunized on the same day, suggests that the hyperimmunizing hog cholera virus used might have been contaminated with the virus of vesicular stomatitis, although the incubation period of 12 days is longer than that previously reported by this method of exposure. It is possible, however, that the simultaneous injection of large quantities of hog cholera virus might have retarded the action of the vesicular stomatitis virus.

If the disease had been brought to the establishment in a group of virus pigs, it should have been present on some farm in Kansas or Missouri. Careful inspection of the farms from which these swine were obtained revealed no evidence of vesicular stomatitis. There were no reports of vesicular stomatitis in Kansas or Missouri during 1943, according to the livestock officials of those States. Inspections of all premises from which the immune hogs were obtained were likewise negative for vesicular stomatitis. Despite these findings, however, there is a slight possibility that one of the virus pigs had an inapparent vesicular stomatitis blood infection at the time it was used for virus production. If so, a batch of hog cholera virus could thus have been contaminated and when injected intravenously for hyperimmunizing

purposes could have set up vesicular stomatitis in the injected animals. From these animals the disease could have spread by contact, under the existing conditions, to other swine.

The 12 contact calves on the premises were inspected on admission and periodically during the outbreak. As already indicated, none showed evidence of the disease at any time. As vesicular stomatitis can be transmitted only when infected animals show acute evidence of the disease, these contact calves were not the source of this outbreak. Although two of these animals were refractory on inoculation, it is possible either that they might have developed an increased resistance from indirect contact with the sick hogs or that the inoculum used was low in infectivity.

Consideration was given to the possibility of the water or feed supply being a source of the disease. The water supply was from the local city water department and was processed in filtration plants and piped to the establishment. The feed in the hog cholera unit was a mixture of ground grain and minerals placed in self-feeders. This feed had been obtained from the same source for a considerable period. There was no evidence to indicate that these products could have contained the causal agent. As far as the authors are aware, this outbreak is the first in which the disease has been reported as occurring naturally in swine. It has occurred in horses and cattle on many farms on which hogs were present. Swine, however, may be readily infected with the virus by epithelial and intravenous inoculation. After epithelial inoculation, this infection follows a uniform course characterized by primary multiplication of the virus at the site of inoculation, which results in blanching of the epithelium and the formation of vesicles, an acute rise in temperature, and a brief invasion of the blood stream by the virus. The vesicles rupture within a few hours, the affected tissue usually sloughs within a few days, and healing occurs in the usual manner. The height to which the temperature rises and its persistence usually correspond with the severity of local lesions. With the rupture of the vesicles, the temperature drops rapidly. The temperature may remain elevated, however, if there is extension of lesions or secondary lesions. Lesions occur most commonly on the feet, snout, and tongue. In the 11 swine used in the diagnosis of this outbreak, other than those injected intravenously, only 1 developed secondary lesions. The period from the first appearance of symptoms to the beginning of healing of the lesions is brief, usually 72 to 96 hours. The lesions in swine after intravenous inoculation, described on page 9, simulate natural infection in vesicular exanthema and foot-and-mouth disease.

The rapidity of the spread of the disease, the high incidence of infection in the large immune and hyperimmune hogs, and the almost total lack of the disease in the virus, test, and stocker pigs (only 1 positive case in 500) were outstanding features of this outbreak. The reason for these totally different results is believed to be as follows: As shown in figure 1, the temperature pens were in the north end of the large hog unit. The north end of the east alley was also used for the same purpose. When temperatures of the 60 Memphis hyperimmunes from pens 3 and 4 were being taken prior to the first bleeding, 35 were found to have high temperatures, and a number of these animals were reported to be lame. It is evident, therefore, that the disease was then in its vesicular stage, and as a result the west alley, the tempera-

ture pens, and the north end of the east alley were heavily contaminated with concentrated virus. The floor of this building slopes toward the south. The drains are not in the alleys but inside the pens adjacent to the alleys. Thus when the temperature pens were washed, the washings passed through all pens except Nos. 1, 2, 14, 15, 28, and 29. These drains or gutters were shallow and a favorite spot for the large hogs to lie in when washing was done. The animals so thoroughly blocked the drains that from one-third to one-half of each pen was inundated. This condition naturally resulted in direct exposure, at that time, of practically all these hogs except those in the six pens mentioned. The high incidence of cuts and abrasions on the feet of these garbage-fed hogs probably provided a source of local entrance of the virus, which was the practical equivalent of an artificial inoculation. This would account for the presence of infection in a large number of immune hogs in pens 25, 26, and 27 within a week after their admission to the premises on July 26.

SUMMARY

This circular reports an outbreak of vesicular stomatitis that occurred in 1943 in hog-cholera immune and hyperimmune hogs used in the preparation of anti-hog-cholera serum in a commercial biological establishment at Kansas City, Kans. As far as the authors are aware, this outbreak is the first in which the disease has been reported as occurring naturally in swine.

In this outbreak, 417 of 787 large hogs developed the disease, whereas only 1 of approximately 500 virus, test, and stocker pigs became infected. Twelve yearling calves, exposed by direct and indirect contact to the swine, were refractory to the disease.

In tests made for the purpose of diagnosis, cattle, horses, hogs, and guinea pigs were found to be susceptible to epithelial inoculation, whereas goats were refractory. These findings, as well as results of tests involving intramuscular, subcutaneous, and intravenous inoculations, showed definitely that the disease was vesicular stomatitis. Other tests showed that the virus causing the outbreak was a filter-passing organism, thereby agreeing with the two known types that produced the disease.

Tests in swine of hog-cholera virus and anti-hog-cholera serum prepared prior to the diagnosis of the disease were negative for the presence of the virus of vesicular stomatitis.

No definite source of the virus causing the outbreak was found. Investigation showed no infection (1) on the farms from which any of the hogs used at the establishment were obtained, (2) among the contact calves, or (3) in the feed or water given to the animals. It was concluded, however, that there was a slight possibility that one of the virus pigs had an inapparent vesicular stomatitis blood infection at the time it was used for virus production.

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